

IRRIGATION SYSTEM EFFECTS ON SURVIVAL
OF JUVENILE SPRING CHINOOK AND OTHER SALMONIDS
IN THE DUNGENESS RIVER

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The Dungeness River is unique in western Washington in having irrigation water withdrawn by diversion structures, in contrast to individual pumps placed directly in the river. These diversions occur within the spawning range of the river's spring-summer chinook, early and late pinks, coho, chum, and both summer and winter steelhead. The chinook and pink runs are considered depleted.

This situation, coupled with the potential value of spring chinook, has made restoration of this run a concern for Fisheries Assistance since 1981 (Fisheries Assistance Office 1982). At that time our interest was confined primarily to stock assessment. However, our growing familiarity with the watershed has made it clear that an interagency effort in stock assessment, enhancement, and environmental restoration was required.

To plan for such an effort, the Straits and Hood Canal Subcommittee of the Spring Chinook Technical Committee was formed. This group coordinates spring chinook restoration activities among the Service, the Washington Department of Fisheries, and the Point-No-Point Treaty Council. We presented this group with interagency activity plans on the Dungeness for the past two years (Fisheries Assistance Office 1986, 1987a). These plans have now largely been incorporated into the Strait of Juan de Fuca Salmon and Steelhead Management Plan for Terminal Areas (Winter 1986) in the statewide watershed management process.

Assessing the impact of irrigation has been a major part of these plans. We have identified several possible mechanisms of irrigation impact: (1) degradation of instream habitat due to excessive diversion; (2) impingement of fry on the fish screens due to high velocity of irrigation water through the screens; (3) entrainment of juvenile salmonids into the ditches due to poorly fitted screens; and (4) upstream migration of juvenile salmonids into ditches by way of unscreened tailwaters.

Regarding degradation of instream habitat, we have examined the relation between summer low flows, irrigation diversion, and historical run sizes (Hiss 1987). The data suggested that low flows during spawning and incubation may have affected adult returns four or five years afterwards. Based on our assessment,

we recommended an instream flow incremental study to assess the impact of diversion on spring chinook holding, spawning, and passage (Fisheries Assistance 1987b).

To address the concerns of impingement, entrainment, and entry through tailwaters, we cooperated with Fisheries and with the Washington Department of Ecology in field studies between November 1986 and June 1987. This report evaluates the results of this work.

STUDY AREA

The Dungeness River originates in the Olympic Range and flows northward into the Straits of Juan de Fuca. The river has five irrigation diversions, known as

Agnew	Left bank	Mile 11.0,
Highland	Right bank	Mile 10.9,
Independent	Right bank	Mile 8.5,
Cline-Clallam-Dungeness	Left bank	Mile 7.5, and
Sequim Prairie	Right bank	Mile 6.8.

Each diversion has a headgate which is manually adjusted weekly to regulate the amount of water taken from the river. From the headgates water passes to fish screens. These consist of two or three rotating drums, each about ten feet long. The Agnew, Independent, and Sequim Prairie screens are steeply angled to the flow, thus setting up a current parallel to the screens that guides fish to a bypass port at the downstream end. The other two diversions have screens perpendicular to the flow, and fish bypass ports are provided at one or both ends of each screen. In either case, flow from each bypass port passes through a vertical concrete shaft into a culvert leading back to the river.

Irrigation can affect juvenile salmonids at all points through their outmigrant season because some withdrawal occurs year-round (Table 1). Irrigation is of special concern for age-0 outmigrants, which have less resistance than yearlings to impingement and entrainment because of their small size. Age-0 outmigrants on the Dungeness include chinook, based on analysis of the few available adult scale samples, as well as pink and chum. It can be assumed that most fry have emerged from the gravel by February and have migrated to the ocean by June. Virtually all outmigrant chinook are affected by the diversions, since in 1986 9.0% of the spawning occurred below Mile 6.4 and 67% occurred above Mile 10.8 (Graeber 1987).

Table 1. Monthly flows and irrigation diversion on the Dungeness River.

Month	Discharge at Mile 11.4 (a)	Irrigation diversion (b)	Percent diverted
Jan	353	28	7.9
Feb	318	24	7.5
Mar	243	23	9.5
Apr	302	53	17.5
May	560	120	21.4
Jun	694	116	16.7
Jul	491	118	24.0
Aug	295	115	39.0
Sep	186	76	40.9
Oct	223	48	21.5
Nov	340	46	13.5
Dec	412	32	7.8
Jan	397	28	7.1

(a) Source: U.S. Geological Survey records, 1942-76.

(b) Source: Drost 1986. Average of 1978-79.

POTENTIAL IMPINGEMENT OF SALMONID FRY ONTO IRRIGATION SCREENS

Juvenile salmonids migrating downstream may be pinned, or impinged, against the face of an irrigation screen if the water velocity perpendicular to the screen is excessive. Fisheries requires velocities of no more than 0.5 feet per second perpendicular (in the horizontal plane) to irrigation screens at any point on the face of the screen (Ken Bates, Fisheries, personal communication). We cooperated with Ecology to assess compliance with this criterion on the Dungeness.

Methods

To document actual impingement we visually inspected each screen for juvenile salmonids impinged or obviously stressed. To evaluate the potential for impingement based on current velocity, we estimated maximum horizontal velocities perpendicular to the screens. At each diversion we visually selected one or more points along the length of the screens where perpendicular flow appeared greatest. At each of these points we measured the velocity at elevations of 80%, 50%, and 20% of the water depth at the nose of the screen. We used a Swoffer Meter (no endorsement implied) with a two-inch diameter propeller-shaped rotor mounted on a U.S. Geological Survey wading rod. We pointed the rotor into the direction of maximum velocity. To obtain the perpendicular velocity we visually estimated the angle of rotor from the face of the screen, and multiplied the sine of this

angle by the maximum velocity. Measurements were repeated three times from April through June to represent a range of flows at the screens. Fish bypass ports and vertical shafts were also examined to suggest whether velocities and direction of flow might lead to impingement or abrasion in the shafts.

Results and Discussion

No impinged or stressed fish were seen on any screen on any of the three dates. Our observations cannot be considered conclusive, however, because our visits were not scheduled to coincide with peak smolt outmigration, and our observations were not frequent enough to monitor daily or hourly peaks in migration.

Impingement could still occur, judging from the current velocities at the screens. Perpendicular approach velocity exceeded the Fisheries criterion at all or most of the diversions on all dates (Table 2; more detailed data appear in the Appendix). Magnitude of maximum velocities was not apparently related to water level at the face of each screen (Table 2). This implies that there is no direct relation between maximum velocity and total amount diverted from the river at each site. It was clear that problems could just as easily occur before, as well as during, the irrigation season. Excessively high velocities did not occur over the entire screen but were concentrated in "hotspots" ranging from ten to twenty percent of the length of the screen. These locations varied over time, presumably because of adjustments in the operation of the diversion. Maximum velocities occurred predominantly at an elevation of 80% of the water depth.

Factors contributing to unevenness of flows may be (1) the shape of the concrete screen bays (in the case of angled screens), (2) the position of the adjustable baffles upstream and downstream of the screens, (3) the degree to which fish bypass ports were opened, (4) the amount of sediment accumulated just upstream of the screens, and (5) the fact that during low diversion flow not all screens were kept rotating. Individual factors probably have varying importance at the respective screen sites.

The vertical shafts of fish bypasses at Agnew, Highland, and Cline-Clallam-Dungeness could have problems from the velocity at which fish strike the shaft wall. Additionally, at the Highland diversion the bypass water at both ends of the screens glances off a nearly parallel concrete wall before striking a perpendicular wall. There may be potential for abrasion of fish there. Another potential problem is that the metal bypass gate near the left bank has a vertical quarter-inch gap running its length where it should be sealed onto the concrete body of the screen bay. Fish could get stuck in this gap, although this was not observed.

Table 2. Maximum perpendicular velocities at irrigation screens on Dungeness River, spring of 1987.

Screen	Water level (ft.)	Date	Location & elevation			Perpendicular velocity (ft./sec.)
			Drum no. (a)	Panel no. (b)	% of water depth	
Agnew	3.1	6-9	1	3	80	0.53
	3.4	4-7	1	2	80	1.01
	4.6	5-27	2	1	80	0.62
Highland	2.6	4-7	1	4	80	0.71
	2.8	5-27	2	2	80	1.50
	3.2	6-9	2	1	80	1.09
Independent	1.4	4-7	2	3	80	1.96
	1.8	6-9	2	3	20	2.04
	2.9	5-27	2	2	80	1.19
Cline-Clallam -Dungeness	2.4	4-7	1	5	80	2.03
	3.0	5-27	2	3	80	1.96
	3.0	6-9	2	4	80	1.48
Sequim Prairie	1.5	4-7	2	1	80	0.45
	2.3	6-9	2	5	20	1.24
	2.5	5-27	2	3	80	1.74

(a) Drums are numbered beginning with the one closest to the gate in the fence surrounding the screens.

(b) Each drum has five panels of wire mesh. These are numbered starting with the panel closest to the gate for each screen.

Recommendations

Based on the above discussion, the following steps are recommended to spread flows evenly over the face of the screens. Determination of whether the screens pose an inherent danger of fish loss by impingement will depend on measurements taken after flows have been evened out. Steps can also be taken to lessen the possibility of impingement and abrasion of fish in the bypass shafts. Site-specific recommendations are:

Agnew. Explore whether some closing of the bypass gate downstream of the screens will result in lower flow into the downstream end of the screen.

Highland. Install baffles in the slots downstream of the screens, and attempt to shape each baffle to direct flow away from the central pier between the two drums.

Independent. See if raising the baffle downstream from the screens on the side farthest from the maintenance gate will result in more even flow through the screens.

Cline-Clallam-Dungeness. (1) Lower the baffles immediately upstream of the drums, so that flow is less concentrated on the upper half of the drums. (2) Clean out all accumulated silt and gravel above these baffles. (3) Open all fish bypasses and balance flow among them. (4) Replace notched stoplogs now in the wells with slotted gates so that excessive head does not develop over the outlet. (5) Raise elevation of baffles downstream of the center bay to direct more flow through the side bays.

Sequim Prairie. See if raising the baffle downstream from the screens on the side farthest from the maintenance gate will result in more even flow through the screens.

At all diversions. (1) Run all revolving drums throughout the outmigrant season, which can be presumed to occur from February through June. (2) Readjust baffles and ports whenever substantial changes in irrigation flow have occurred. (3) Obtain expert evaluation of impingement and abrasion potential in bypass shafts.

ENTRAINMENT OF SALMONID FRY INTO IRRIGATION DITCHES

The irrigation water from the five diversions enters a total of eight ditch systems. These consist of several miles of main ditches and many lateral branches from which farmers withdraw water using screened pumps. The ditch systems are not managed for fish production because the ditches are dried for several days in early spring for periodic maintenance. At other times, fish in the lower reaches and lateral branches are still subject to fluctuating water levels, high temperatures, and runoff of manure, fertilizers, pesticides, and herbicides.

To roughly evaluate the extent of entrainment, Fisheries assessed the occurrence of salmonids in the ditches for several hundred feet immediately downstream of the screens in early November of 1986. Immediately afterwards they replaced the gaskets of each screen where needed to make the screens as fish-tight as possible. In March of 1987 Fisheries and Fisheries Assistance jointly evaluated the success of repairs by repeating the fish collection procedure. We report here the results of both field efforts.

Methods

Fish were collected by backpack electroshocker using low-frequency pulsating direct current. Fish were then anesthetized, identified to genus or species, measured for fork length, and

returned to the river. No attempt was made to estimate population density. The gear, area shocked, and degree of effort were approximately the same in March as in November.

Results and Discussion

Fisheries discovered juvenile salmonids downstream from the screens in all five ditches in November before repairs were made (Table 3). Some chinook were reported in the catches, although the ditches in which this species occurred were not identified. Nor was the relative abundance of chinook versus other salmon species recorded. Occurrence of chinook in November is unusual, because scale samples suggest that most chinook migrate to sea in the spring after only a few months in the river. Age-0 outmigration is also the rule in other populations in Puget Sound and coastal Washington.

Fisheries personnel attributed the presence of fish in the Cline-Clallam-Dungeness and Highland ditches in November to gaps between the screens and the gaskets on the walls of the flume. These gaskets were subsequently replaced. Fisheries found the Agnew, Sequim Prairie, and Independence screens and their gaskets to be in good repair. The fish collected from these ditches could have entered the Cline-Clallam-Dungeness and Independent Ditches from Matriotti and Bell Creeks, respectively. Another source of fish in all ditch systems could be unscreened farm ponds. These ponds could have received juvenile salmon as well as trout from various sources, including netting from the wild.

In spring, after the repairs, far fewer fish were collected. The decrease in chinook in the Highland and Cline-Clallam-Dungeness Diversions coincides with the repairs performed there. Fisheries technicians familiar with screening believe that the screens are now as fish-tight as possible. One could examine this argument by shocking in the mainstem, but regardless of the results it is not clear what more can, or should, be done to keep fish from passing around the screens.

The decrease in numbers of trout in all ditches, even those which had no repairs made, suggests that most trout enter the ditches after March. Entry from local creeks is a tempting hypothesis because the ditches with the most trout in November were those ditches whose tailwaters were accessible from either Matriotti Creek or Bell Creek.

Table 3. Electrochocking catch of salmonids in Dungeness River irrigation ditches.

Location	Juvenile salmon		Juvenile trout	
	Nov. 1986 (a)	March 1987 (b)	Nov. 1986 (c)	March 1987 (c)
Agnew	5	1	72	1
Highland	44	2	39	1
Independent	1	0	203	0
Cline-Clallam-	45	2	168	1
Dungeness				
Sequim Prairie	3	0	few	12

(a) Chinook and/or coho.

(b) All age-0 chinook.

(c) Predominantly rainbow, steelhead and/or cutthroat not yet distinguishable from steelhead.

POTENTIAL ENTRY OF JUVENILE SALMONIDS INTO TAILWATERS OF IRRIGATION DITCHES

The irrigation companies maintain a certain flow at the end of the main ditches to keep water levels high enough for farmers to run their pumps. The flow which is not pumped out is known as the tailwater. Some tailwaters are allowed to flow, unscreened, into nearby natural streams, some of which support anadromous fish. The danger to these fish is that juveniles may migrate upstream into the ditches and attempt to rear there. However, conditions in the ditches are not considered conducive to good survival.

To prevent fish entry, Fisheries requires that all tailwaters emptying into anadromous waters be fitted with fish barriers. To assess compliance, Fisheries Assistance made a preliminary list of fifteen tailwaters based on irrigation maps, and visited several sites to assess fish passage in the fall of 1986. In March of 1987 Fisheries completed the survey and listed all accessible tailwaters.

Fisheries confirmed passability at three sites, the first two of which could impact chinook. The first was at the end of Clallam Ditch where it enters Matriotti Creek. This occurs just west of Cays Road between the Old Olympic Highway and Woodcock Road. Matriotti Creek supports a coho run and chinook have access to it from the mainstem Dungeness.

The second site was at the end of a lateral off Cline Ditch where it enters Matriotti Creek. This occurs northwest of the town of Carlsborg along Spath Road just north of where it crosses Matriotti Creek. Juvenile chinook may have access to this point as well.

The third site was at the end of the south branch of Independent Ditch where it enters Bell Creek. This tailwater is south of the town of Sequim, just west of Sequim Avenue and immediately south of the railroad track. Bell Creek is known to support a coho run, but chinook probably do not occur there.

Fisheries also pointed out a small, unscreened diversion from Hurd Creek. This is a tributary to the Dungeness at about Mile 3.0. It is possible that some chinook enter here, especially since chinook have been reared on this stream until 1982.

We recommend that some type of fish barrier be installed at each of these sites. Priority should be given to the tailwater near Cays Road. This site is most accessible to chinook since it is closest to the mainstem Dungeness. Moreover, it appears to have more flow than the other tailwaters. A barrier could take the form of a screen, a dam, or some other structure.

SUMMARY

The irrigation diversions along the Dungeness River are screened to prevent fish from entering because conditions are not considered suitable for anadromous fish rearing in the ditches. However, the fish screens at all five irrigation diversions on the Dungeness River pose a potential danger to outmigrant salmonid fry. This is because the current velocities we measured were considered strong enough to pin the fish onto the screen at some points. To eliminate these spots we recommended certain steps to even the flows out along the face of the screens. If this succeeds in eliminating the high velocity spots, than impingement will no longer be a threat.

Juvenile salmon seemed to be passing around the screens into some of the ditches, as suggested by fish collections made in November of 1986. Therefore, the screens were inspected and made as fish-tight as is technically possible. This seemed to greatly reduce the number of juvenile salmon in the ditches, based on fish collections in March of 1987.

In spite of these repairs, fish can still enter some of the ditches by swimming up from the natural streams into which some of the ditches empty. Installation of fish barriers here is recommended.

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APPENDIX : APPROACH VELOCITY DATA

Table 1. Perpendicular velocities at irrigation screens on Dungeness River, spring of 1987. These points were determined visually to represent the highest velocity along the face of the drum.

Screen	Date	Location		Water depth (ft.)	Perpendicular velocity(ft./sec.)		
		Drum no. (a)	Panel no. (b)		80% of elev.	50% of elev.	20% of elev.
Agnew (Mile 11.0)	4-7	1	2	3.4	1.01	0.70	0.53
		2	1	3.3	0.89	0.98	0.58
	5-27	2	1	4.6	0.62	(c)	(c)
	6-9	1	3	3.1	0.53	0.48	0.32
Highland (Mile 10.9)	4-7	1	4	2.6	0.71	0.54	0.09
	5-27	1	2	2.7	0.96	0.83	0.18
		2	2	2.8	1.50	1.01	0.09
	6-9	2	1	3.2	1.09	0.81	0.04
Independent (Mile 8.5)	4-7	2	3	1.4	1.96	1.68	0.69
	5-27	2	2	2.9	1.19	1.00	1.04
	6-9	2	3	1.8	0.74	1.61	2.04
Cline-Clallam -Dungeness (Mile 7.5)	4-7	1	1	2.0	0.67	0.09	0.36
		1	5	2.4	2.03	0.32	0.78
		2	1	2.0	1.57	0.98	0.39
	5-27	1	3	3.3	0.79	0.76	0.22
		2	3	3.0	1.96	0.77	0.48
		3	4	2.6	0.67	0.53	0.07
	6-9	2	4	3.0	1.48	0.30	0.53
Sequim Prairie (Mile 6.8)	4-7	2	1	1.5	0.45	0.23	0.33
	5-27	2	3	2.5	1.74	1.26	0.47
	6-9	2	5	2.3	0.63	1.10	1.24

(a) Drums are numbered beginning with the one closest to the gate in the fence surrounding the screens.

(b) Each drum has five panels of wire mesh. These are numbered starting with the panel closest to the gate for each screen.

(c) Data not available.